Using Lightning Data to Improve Satellite Rain Estimates

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Lightning Enhanced Microwave Rainfall Estimates

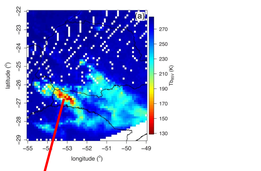
1. Introduction

GOES-R will fly two major weather instruments : the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM). The rainfall algorithm (QPE) from ABI requires microwave-based rain-rates as a calibration target, where the upcoming GPM mission will be of great value.

Microwave rainfall signals are sensitive to the presence of precipitation-sized ice, which is the key parameter for lightning generation. Lightning activity is also a good indicator of deep convection. One of the major difficulties in microwave rainfall retrievals over land is to delineate convective and stratiform rain. This study is to investigate the lightning and microwave connections through the ice microphysics and convection strength, and use these connections to improve the microwave segregation of rainfall in convective and stratiform. The ultimate goal is to refine microwave rainfall estimates necessary for the GOES-R QPE.

2. Microwave-Lightning Connections

TRMM October 10, 2004 over Brazil
(TRMM orbit #39346)



TMI 85 GHz V-pol TBs

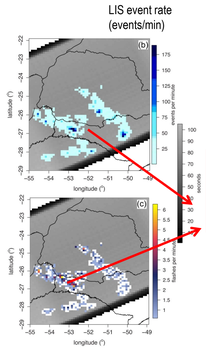
low 85 GHz TB, indicate Ice scattering

Ice, mixed -phase

Microwave + Lightning

delineate Convective/Stratiform

Rain Rate



LIS event rate (events/min)

Lightning, indicate presence of ice, convection, how to relate to passive microwave rainfall?

LIS flash rate (events/min)

3. Algorithm Descriptions

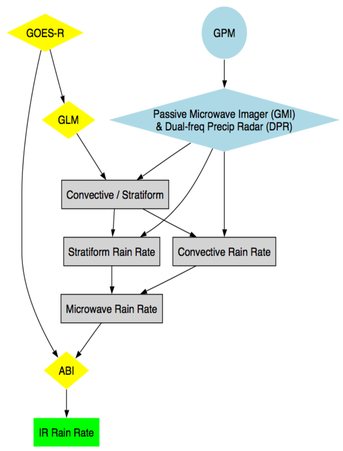
Microwave rain-rate

RR = RRconv P(C) +RRstrat (1 - P(C))

where P(C) is convective ratio, and RRconv and RRstrat are convective and stratifrom rain-rates, respectively.

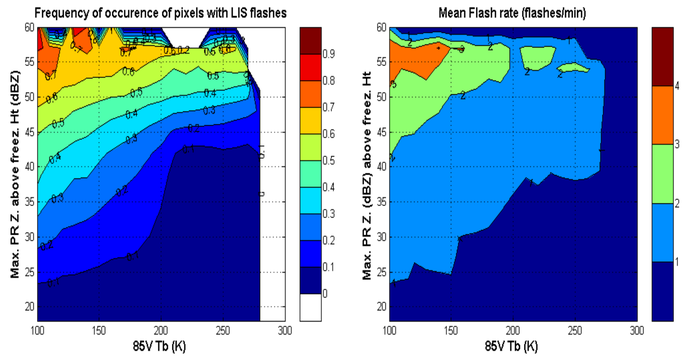
$P(C) = a_1 TB10V + a_2 (TB37V+TB85V)/2 + a_3 NPOL + a_4 STDEV + a_5 MINIMA + k$

- Explore the use of lightning data with passive microwave. (a) we've done: use lightning flash rates to sort pixel-by-pixel microwave TBs and convective fractions P(C) w.r.t. lightning intensity. Convective fraction P(C) becomes a function of lightning intensity for each pixel (b) we're exploring the convective features.



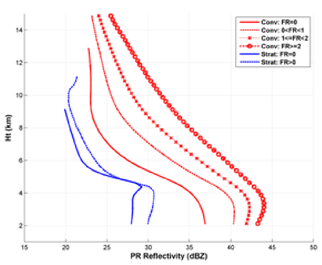
4. Lightning and Microwave Relationships

14 Millions raining pixels from Jan 2002 – Dec 2004

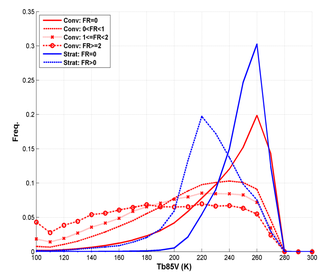


Lightning is obviously useful in identifying deep convection!

Median radar profiles with and w/o lightning



85 GHz TB distribution with and w/o lightning



7. Conclusions

- **There are strong relationships between the occurrence and frequency of lightning, radar reflectivity, and microwave 85 GHz *TBs*.**
- **Preliminary results indicate <u>obvious value of lightning information</u> to establish convective strength underestimated by passive microwave. Preliminary statistics indicate improvement in rain estimation with use of lightning data.**
- **Results reveal that lightning flash rates primarily improves the identification of deep convection and heavy convective rainfall ; Bias error reduction of 6% and RMS error increase of 4.5%.**
- **A journal article was published entitled "Application of lightning to passive microwave convective and stratiform partitioning in passive microwave rainfall retrieval algorithm over land from TRMM", 2012, JGR, DOI:10.10292012JD17812**

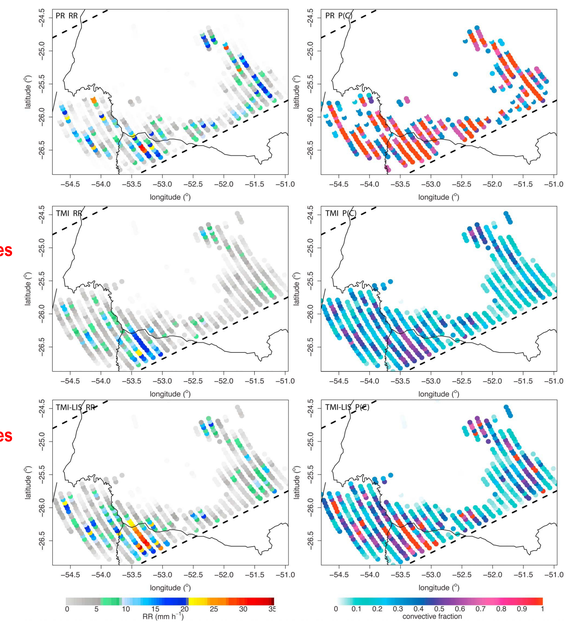
5. Lightning Statistics over Land

- **Four years, 14M TRMM TMI/PR/LIS over land precipitation data (in 0.1° grid resolution) reveal that**
  - **–6% of rain data has lightning flash rate > 0 fl/min**
  - **–13.5% of the lightning occur in stratiform, 86.5% in convective**
  - **–convective rain probability increases with increasing lightning frequency. 34% of rainfall is convective for low flash rates (0-1 fl/min), whereas the convective probability increases to 99.7% for high flash rates (>= 2 fl/min).**

6. Performance of Enhanced Algorithm

Microwave rain estimates w/o lightning

Microwave rain estimates with lightning



Lightning information improves microwave convective-stratiform separation and rain estimation!

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